INTER-REGIONAL TRANSMISSION: ARE WE THERE YET?

PLANNING THE NEXT ROUND OF TRANSMISSION FOR RENEWABLES

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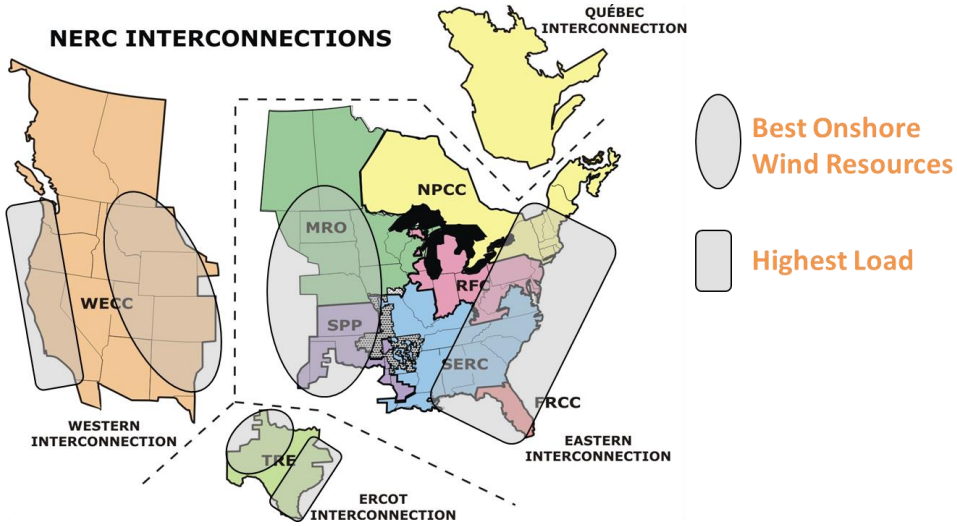
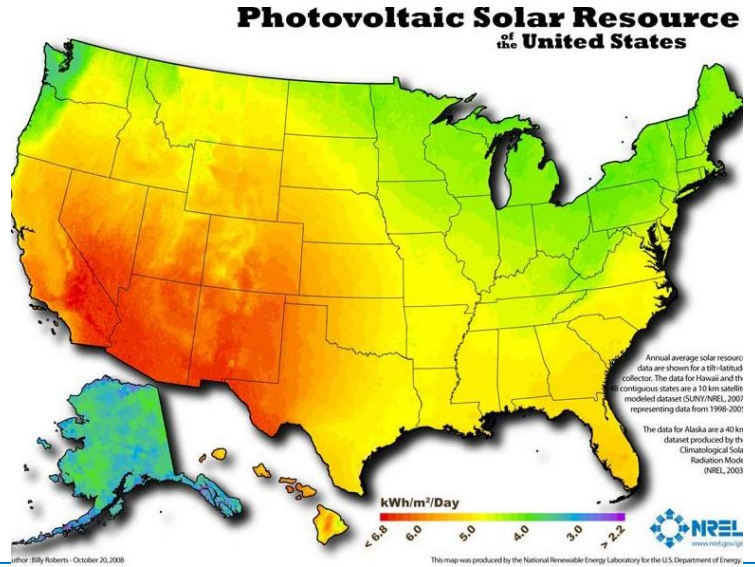
"NEXT" ROUND? WE HAD A FIRST ROUND?

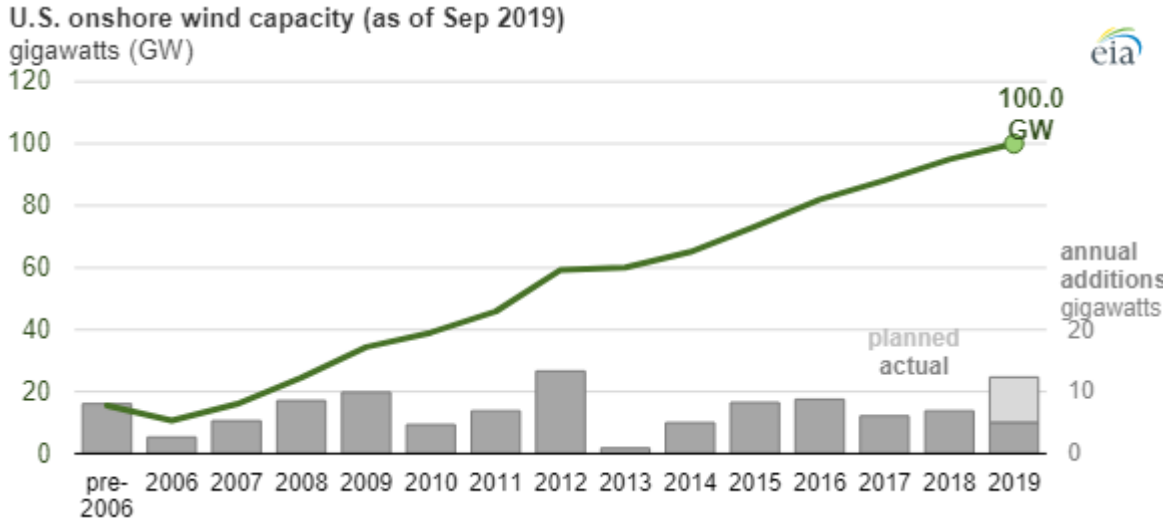
- As a matter of fact, yes.
- Best renewable resource areas do not align with geographic layout of electric demand
- FERC Order 1000 set the framework for expanding transmission to accommodate increased renewable generation (RTO transmission expansion planning processes)
- Substantial transmission investment over last decade to assist with integration of growing bulk renewable generation



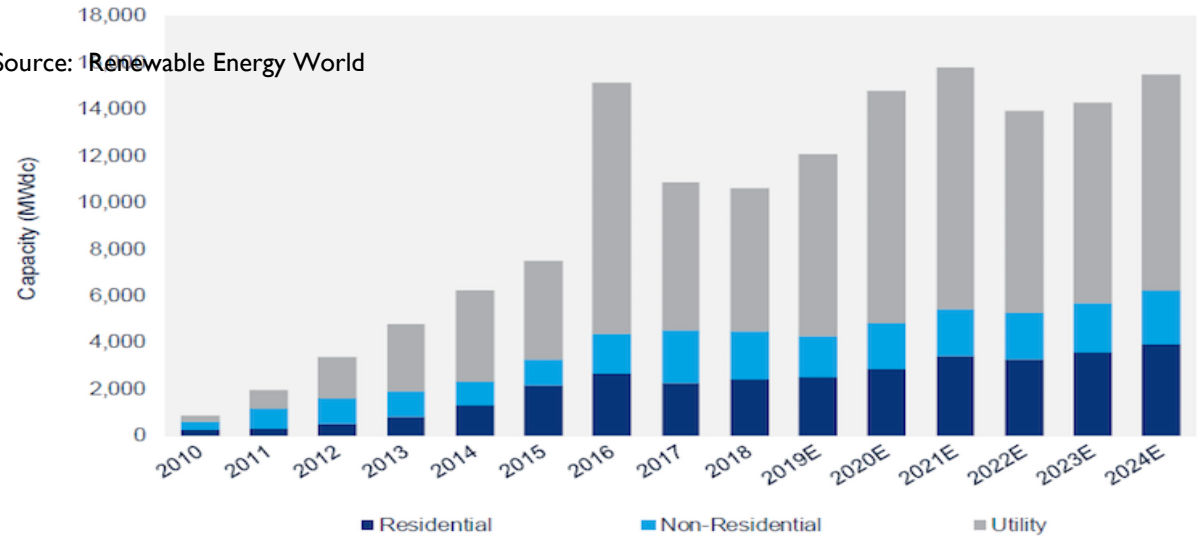


SO HOW FAR HAS THIS GOTTEN US?

- Bulk wind generation capacity > 110 GW
- Solar PV approaching 70 GW (all types, with bulk-connected systems largest fraction)
- Combination accounts for less than 10% of US electric energy production
- Continues to be major driver for regional transmission planning
- Current fleet is motivating some RTOs to look for inter-regional solutions
- Status quo, two-year cycles with maybe 10 year outlooks

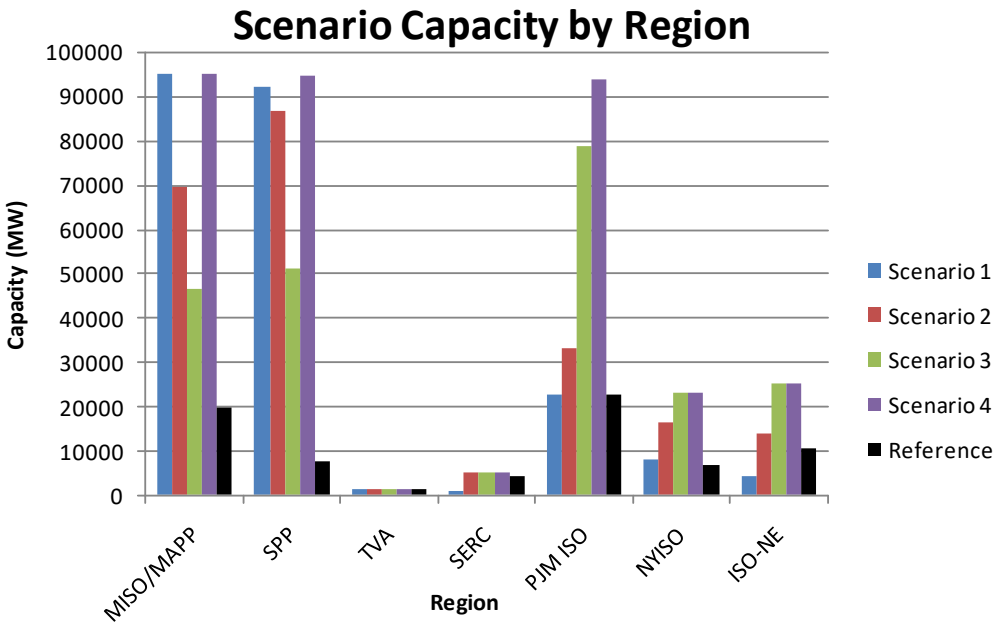


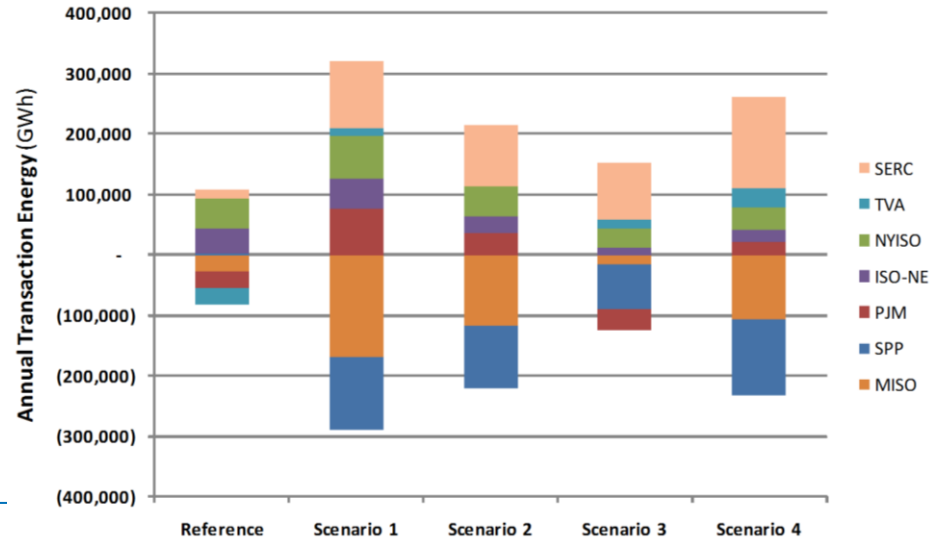
Source: Renewable Energy World



SOME CONTEXT

- Some studies conducted beginning a decade ago assessed transmission needs and opportunities for significantly higher penetrations of renewable generation
- While not transmission "plans", the general conclusions from those efforts help to place our current situation in perspective
- e.g. EWITS (Eastern Wind Integration & Transmission Study)
  - Considered 20% + of Eastern Interconnection energy from bulk wind generation
  - Equates to 230+ GW of bulk wind generation
  - *Twice* the current installed US fleet





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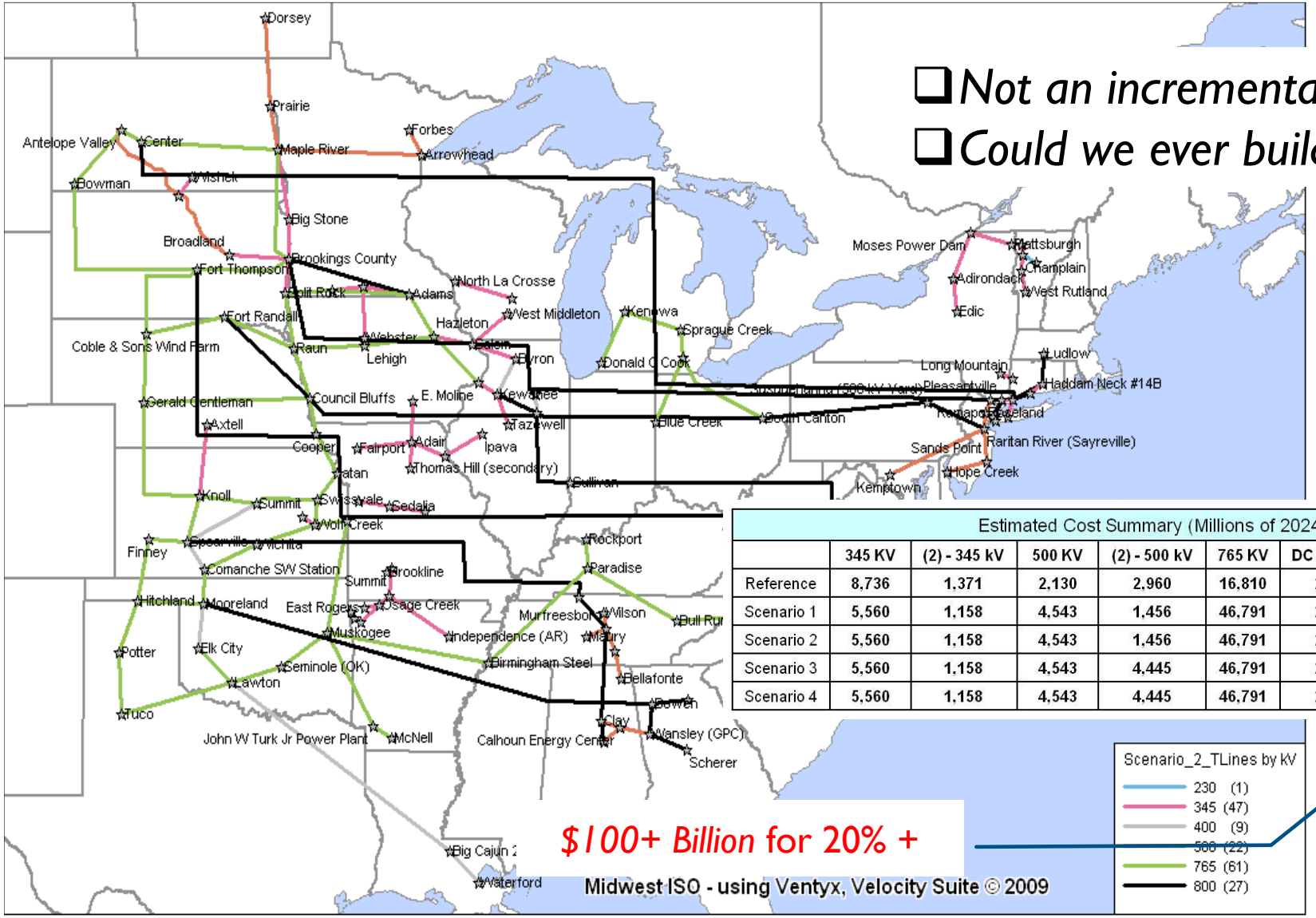
EWITS TRANSMISSION CONCEPTS



- *Not an incremental view*
- *Could we ever build this?*

Estimated Cost Summary (Millions of 2024$)

	345 KV	(2) - 345 kV	500 KV	(2) - 500 kV	765 KV	DC - 400 kV	DC - 800 kV	Total
Reference	8,736	1,371	2,130	2,960	16,810	2,155	14,400	48,562
Scenario 1	5,560	1,158	4,543	1,456	46,791	2,397	83,265	145,169
Scenario 2	5,560	1,158	4,543	1,456	46,791	2,397	62,640	124,544
Scenario 3	5,560	1,158	4,543	4,445	46,791	2,957	35,603	101,056
Scenario 4	5,560	1,158	4,543	4,445	46,791	2,397	79,296	144,191

$100+ Billion for 20% +

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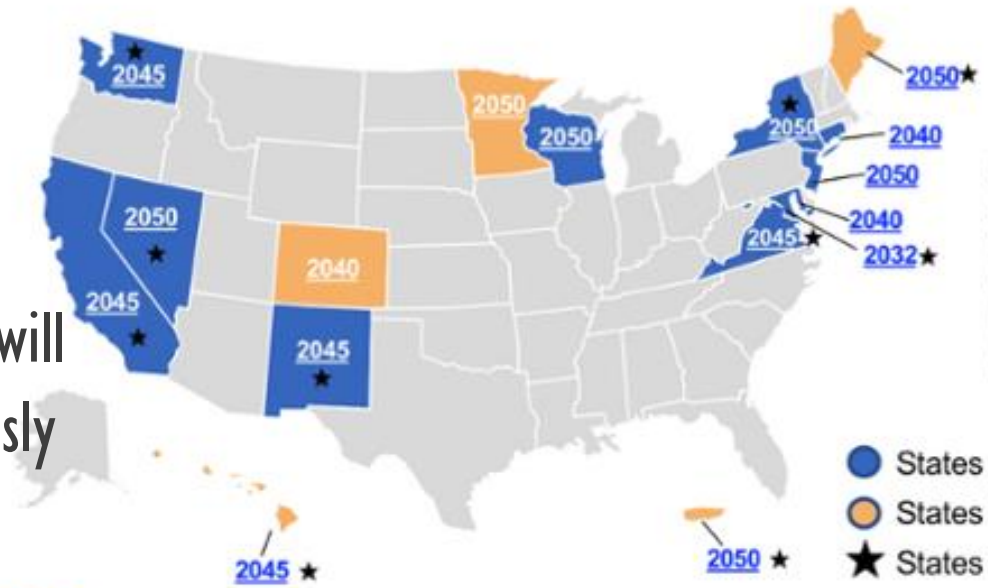
SO, WHAT SHOULD BE CONSIDERED IN THE "NEXT" ROUND?

- Inter-regional development is likely a necessity
- Economics of bulk wind and solar PV, combined with continuing policy incentives and outlook, will continue to drive growth
- Transmission planning space is becoming more complicated with substantial growth of DER, burgeoning offshore wind generation, and emergence of bulk energy storage
- So, current expansion planning must consider ever increasing renewable penetration, but will be challenged by "bottom-up" or "inside-out" perspectives
- But…

. . .ARE WE APPROACHING AN INFLECTION POINT?

- "100% clean energy" and "decarbonization" are relatively recent policy objectives across the US, and gaining some traction
- Implies that future renewable targets will be much higher than we have previously imagined
- Decarbonization of transportation sector would increase electric demand, and therefore renewable energy required to meet policy goals.



Source: Advanced Energy Economy, April 2020

FUTURE TRANSMISSION PLANNING NEEDS, QUESTIONS

- Technically, we have the knowledge and most of the tools needed
  - Higher penetrations of Inverter-Based Resources are current challenge, but work being done
  - New transmission technologies (namely lots of HVDC) may add to study needs
- Normal vs. Extended planning horizons
  - Curently, development of "futures" is large stakeholder process
  - Would ad hoc cooperation between RTOs & their stakeholders be possible?
- Moving from regional (RTO footprint) to inter-regional (many states) or even national viewpoints:
  - Who participates?
  - Who directs process?
  - How are decisions reached?
  - Who "drives"?

SUMMARY

- We may be very close to "outgrowing" our transmission planning infrastructure
- Quantities of renewable generation already under consideration require larger view
- Would current transmission expansion process lead to a bulk system that can support a dramatically different future?
- If not, what do we need instead or in addition?
- A tempting analogy: National Defense Highway Act (interstate highways) – relic from the past or are there some relevant lessons for the future.

Thanks

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